Haruo OKUNO[*]: Electron-microscopical study on antarctic diatoms (3)

奥 野 春 雄[*]: 南氷洋産珪藻の電子顯微鏡的研究 (3)

Asteromphalus Hookeri Ehrenberg (Text fig. I, C, C'; Pl. I, figs. 1, 1'), A. Schmidt, Atlas Diat. pl. 38, figs. 18-20 (1886); Karsten, Phytopl. Antarkt. Meer.: 90, pl. 8, figs. 9, 10, 12 (1905); Boyer, Synop. North Amer. Diat. **1**: 74 (1926); Mills, Index Diat.: 219 (1933); Boden, Trans. R. Soc. S. Afr. **32**:354, fig. 30 (1950).

L. M. S.[**] (fig. 1) Frustules disc-shaped. Valves circular, slightly convex, about 80 (64-120)μ in diameter. Hyaline area almost central, about half the diameter, with straight or slightly crooked rays. Rays usually smooth, sometimes armed with one or two minute spinules near the outer ends. Marginal segments about 7 (5-9). Frustule pores in the segments, in rows parallel or near so to the margin of the segments, arranged in three lines, larger or more prominent on the inner borders of the segments. Interspaces broad, except the one between the two approximate segments.

E. M. S.[***] (Text fig. 1, C, C'; pl. I, fig. 1'). Fragments of valves were observed electron-microscopically by the direct preparations. The central hyaline area and the interspaces between the segments are not porous. The marginal segments are porous. Structures of the loculi in the segments are of the same type as *Asteromphalus heptactis* (cf. Okuno, Journ. Jap. Bot. **26**: 306, pl. 1, figs. 1-1''). Loculi hexagonal, with finely porous sieve membranes, and cover membranes each with a large central cover pore. Sieve pores in a sieve membrane, about 10-13-(usually 4-7 of them can be seen through the cover pore), roundish to elliptic, 3-4 in 1μ, about 120-200 mμ in diameter. The sieve pores divided into many micropores of various shapes by the super-thin dendriform secondary sieve membranes (Text fig. 1, C'). The central pore of the cover membrane roundish, about 500-700 mμ in diameter. St.: no. 27 (++); no. 39 (+); no. 62 (++).

Corethron Valdiviae Karsten (Pl. I, figs. 2'-2'''), Phytopl. Antarkt. Meer.: 101, pl. 12, figs. 1-10, pl. 13, figs. 9-17 (1905); Okuno, Journ. Jap. Bot. **27**: 48, pl. 1, figs. 6-6'' (1952).

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[**] L. M. S.: Light-microscopical structures.

[***] E. M. S.: Electron-microscopical strucures.

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E. M. S. (figs. 2'–2''') I have already reported on the electron-microscopical fine structures of the intercalary bands (scales) (Okuno, 1. c.). Here, I will report on the fine structures of the valve and the long, straight spine which were both observed electron-microscopically by the direct preparations. Valves about 16μ (according to Karsten, to 110μ) in diameter, and porous. Frustule pores in the valve, not locular, elliptic to rectangular as in the intercalary bands, and about 4–5 in 10μ, about 80–100 mμ in major axis, arranged in interrupted radiating rows (fig. 2'''). At the central part of the valve, pores somewhat irregularly scattered. Valve surfaces armed with scattered minute spinules (fig. 2'). Spinules slender, straight, somewhat flexible, about 2.5μ in length, about 0.1μ in diameter at the base. The wall of the spinule somewhat penetrable to the electron beam, but not porous. At the margin of the one valve with a ring of long, straight spines, about 50–400μ in length, about 2μ in diameter (fig. 2''). The spines tubular, somewhat penetrable to the electron beam, but not porous. The electron micrograph of the long spine was shown also by Kolbe (Kolbe, 1948. pl. 6, fig. 12). The spitne armed with spinules, about 2.5–3 in 10μ, directed towards the distal end of the spine.

St.: no. 27 (+++); no. 39 (+); no. 62 (++).

Dactyliosolen antarcticus Castracane (Text fig. 1, E, E'; Pl. I, figs. 3–3'''), Rep. Voy. Challenger, Bot. **2**: 75, pl. 9, fig. 7 (1886); Karsten, Phytopl. Antarkt. Meer.: 93, Pl. 9, fig. 10 (1905); Hustedt, Kieselalg. **1**: 556, fig. 316 (1930); Mills, Index Diat.: 574 (1934); Cupp, Bull. Scrips Inst. Ocean. **5**: 76, fig. 37 (1943); Boden, Journ. Mar. Res. **8**: 8 (1949).

L. M. S. (fig. 3: Fragment of the intercalary bands) Frustules cylindrical, united in long chains by the flat valve surfaces. Valves circular, about 40 (15–75)μ in diameter. Intercalary bands numerous, about 2 in 10μ, halfcollar-shaped, their free ends forming a spiral line around the pervalvar axis. Each intercalary band with a row of coarse or fine frustule pores. Pores in the coarsely porous intercalary bands horseshoe-shaped, about 3 in 10μ; pores in the finely porous ones almost linear-trianguiar, about to 20 in 10μ.

E. M. S. (fig. 3'–3''') Fragments of the valve and the intercalary band were observed electron-microscopically by the direct preparations. Frustule pores seem not locular. In the valve surface, frustule pores linear, radiating from the centre, with undulating lateral margins, about 30 in 10μ (fig. 3'v). The sieve membrane of the frustule pore, very thin, with minute, roundish sieve pores of various diameters. Intercalary bands dimorphic. The one with triangular frustule pores (Text fig. 1, E'; Pl. I, figs. 3'b, 3''), and the other with large horseshoe-shaped frustule pores (Text fig. 1, E; Pl. I, fig. 3'''). These intercalary bards with triangular or horseshoe-shaped frustule pores appear alternately in groups (fig. 3). Triangular frustule pores resemble in their shapes those of the valve surfaces, somewhat linear-triangular, subacute at the apex, ca. 1.6μ high and ca. 0.25μ broad. Sieve pores in a sieve membrane about 5-9, roundish in the centre and curved linear on the margin of the sieve membrane. In the intercalary bands with large frustule pores, the pores are horseshoe-shaped or somewhat oval. In the central part of the sieve membrane, sieve pores irregulary scattered, roundish with various diameters; on the margin, sieve pores curved linear. Diameters of the roundish sieve pores in the valves and intercalary bands about 50-150 mμ. St.: no. 62 (+++).

Chaetoceros criophilum Castracane (Pl. I, figs. 4-4''). Rep. Voy. Challenger, Bot. **2**: 78 (1886); Karsten, Phytopl. Antarkt. Meer.: 118, Pl. 15, figs. 8, 8a-e (1905); Boden, Journ. Mar. Res. 8: 8 (1949).

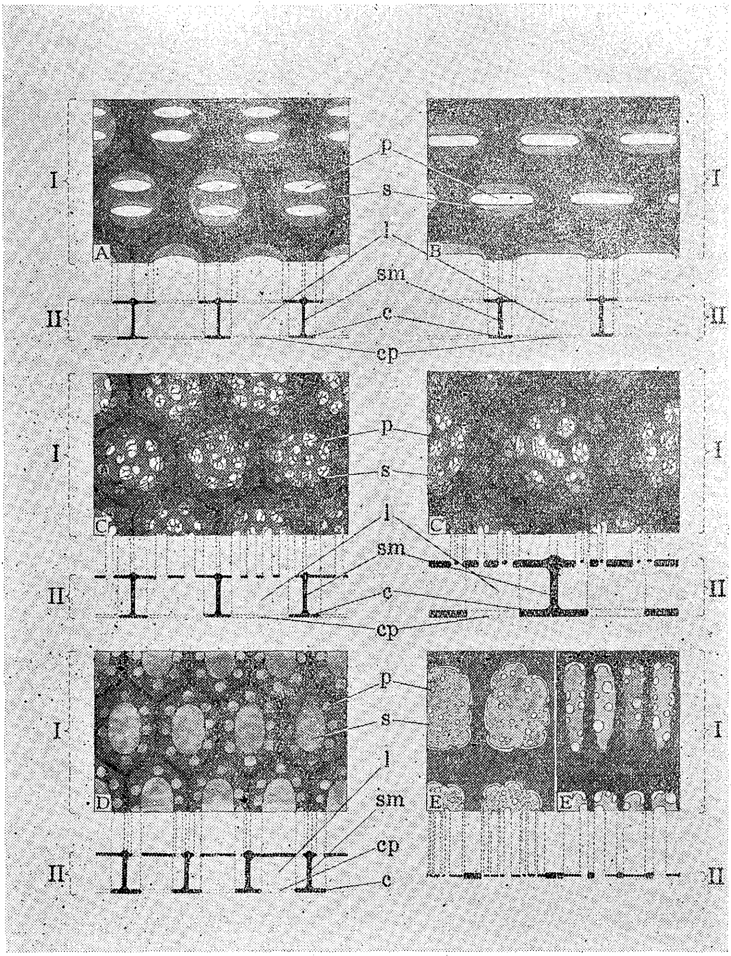
L. M. S. (fig. 4) Cells solitary or in short chains, about 27 (20-32)μ in apical axis. Valves dimorphic. Upper valves with high cylindrical mantles. Valve surfaces concave in the centre. Spines springing at about half the radius of the valve (not so near the centre as in *Chaetoceros concavicornis*!), directed obliquely downwards, somewhat concave on the outer sides. Lower valves with low mantles and flat valve surfaces. Spines springing at about half the radius of the valve. In solitary cells, spines of the lower valve, except the divergent basal part, directed almost vertically downwards. Spines of both upper and lower valves, in their course of length, with minute spinules, directed towards their distal extremities. Spines thin at their bases, somewhat thicker outwards.

Mills made the present species a synonym of *Chaetoceros concavicornis* (Mills, Index Diat.: 379), but this is not correct. The present species distinctly differs from *Chaetoceros concavicornis* in its more distant bases of spines of the upper valve, springing almost horizontally with no vertical portion. And it differs from *Chaetoceros convolutus* in its spines growing thicker outwards.

E. M. S. (figs. 4',4'') In the present research, valve surfaces and the spines of the upper valves were observed electron-microscopically by the direct preparation. Valves porous, with scattered fine frustule pores. Pores not locular, roundish to elliptic. about 130-200 mμ in diameter or in major axis (fig. 4''). Spines impenetrable to the electron beam, armed with short spinules (fig. 4').

St.: no. 27 (+++); no. 39 (++); no. 62 (++).

Eucampia balaustium Castracane (Pl. I, figs. 5. 5'), Rep. Voy. Challenger, Bot. **2**: 97, Pl. 18, fig. 5 (1886); Karsten, Phytopl. Antarkt. Meer.: 120, Pl. **11**, figs. 7, 7a (1905).



Text fig. 1. Diagram of fine structures of frustule pores. A, *Rhizosolenia alata var. inermis*. B, *Rh. bidens*. C, C', *Asteromphalus Hookeri* (C', Details of C). D, *Rh. styliformis* var. *longispina*. E, E', *Dactyliosolen antarcticus* (E. showing the large frustule pores; E', showing the small ones). I, Viewed vertically from above. II, Idealistic cross-section. c, Cover membrane. s, Sieve membrane. sm. Side membrane.

Syn. *Euc. antarctica* (Castr.) Mangin, Mills, Index Diat.: 666 (1934); *Hemiaulus glacialis* Castracane, Okuno, Journ. Jap. Bot. **27**: 47, Pl. 1, figs. 4, 4' (1952).

L. M. S. (fig. 5) Valves about 20–40μ in apical axis. Frustules united in chains by the apices of the processes. The terminal processes of the end cells of chains, often acuminate. Frustule pores in the valve, about 4–5 in 10μ. Intercalary bands ring-shaped, finely porous.

E. M. S. (fig. 5'; cf. Okuno, l. c. 1952) Fragments of the valve and the intercalary band were observed electron-microscopically by the direct preparations. Frustule pores in the valve seem not locular or incompletely locular, roundish-polygonal, with finely netveined sieve membranes. Sieve pores in a small frustule pore about 5, in a large one increase to about 120. Sieve pores about 4–6 in 1μ, in the central part of a sieve membrane usually roundish-polygonal, on the margin, straight or curved linear (fig. 5' v). Intercalary bands about 4 in 10μ, imbricated alternately, finely porous. Frustule pores in the intercalary bands, not locular, about 3–4 in 1μ, linear, linear-elliptic, or roundish, arranged in longitudinal rows about 30 in 10μ (fig. 5'b).

St.: no. 39 (+); no, 62 (+).

Rhizosolenia styliformis Brightwell var. **longispina** Hustedt (Text fig. 1, D; Pl. II, figs. 1–1''), Cupp, Bull. Scrip. Inst. Ocean, **5**: 87, fig. 48-b (1943); Boden, Journ. Mar. Res. **8**: 8 (1949); Okuno, Journ. Jap. Bot. **27**: 47, Pl. 1, figs. 1, 1' (1952).

L. M. S. (fig. 1) Frustules about 27 (20–70)μ in diameter. Calyptra with a distinct impression of the adjoining frustule. Intercalary bands scale-like, rhombic, in two dorsiventral rows.

E. M. S. (Text fig. 1, D; Pl. II, figs. 1', 1'') I reported already on a type of the frustule pore of the intercalary bands of the same variety (Okuno, l. c.). Recentey, I found another type of the frustule pore in a cell of the same variety. In the present cell, which was observed electron-microscopically by the direct preparation, the hexagonal outline, number, and arrangement of the frustule pores in the intercalary bands were similar to the former frustule. The noticeable difference between these two kinds of frustules is the type of their sieve membranes. The sieve membranes of the frustule presented here have 8–10 roundish, marginal sieve pores, about 70 mμ in diameter, as in the next variety *latissima* (fig. 2'''), and *Biddulphia sinensis* (Kolbe, Ark. Bot. **33**: 10, Pl. 3, figs. 5, 6; Okuno, Electr. Diat. IX, Bot. Mag. Tokyo, in press), instead of linear sieve pores (cf. Okuno, l. c.). The linear sieve pores found in the previous research rather resemble those of *Rhizosolenia bidens* (Pl. II, figs. 3', 3''), *Rhizosolenia hebetata* f. *semispina* (Pl. II, fig. 4'), *Rhizosolenia Temperei* (Okuno, Journ. Jap. Bot. **27**: 47, Pl. 1, fig. 2). And the round, marginal sieve pores resemble those of *Rhizosolenia styliformis* var. *latissima* and *Biddulphia sinensis*. According to my research of the past in cells of the same species or variety, the frustule pores were found to be of the same type. And such a dimorphism of the frustule pores found in the present variety was rather an exception. In the present frustule, at the imbrications of two adjoining intercalary bands, fine combteeth-like thickenings, ca. 60 mμ broad, ca. 7 in 1μ, run vertically from the imbrications to one side, extending straightly on the sieve membranes of one or three loculi (fig. 1''). Thus about one to three rows of sieve membranes at one side of the imbrications have 1–3 slit-like pseudo-sievepores, beside the marginal, roundish true sieve pores.

St.: no. 62 (+).

Rhizosolenia styliformis Brightwell var. **latissima** Brightwell (Pl. II, figs. 2–2'''), Hustedt, Kieselalg. **1**: 586, fig. 335a–c (1930); Mills, Index Diat.: 1410 (1934).

L. M. S. (fig. 2: Intercalary bands) The present variety differs from the type and the previous variety, in its larger diameter, about 145 (145–235)μ, and its denser intercalary bands, about 6 (6–12) in 100μ.

E. M. S. (figs. 2'–2''') Fragments of frustules were observed electron-microscopically by the direct preparations. Frustule pores locular, in the impression of the calyptra usually rectangular (fig. 2''), 20–30 in 10μ in logitudinal rows, and covergent at the apex. At other parts of the calyptra and in intercalary bands, loculi rectangular or hexagonal, 16–22 in 10μ, in three rows decussating at about 60 degrees (fig. 2'). The fine structure of the loculus is similar to that of the previous variety. The sieve membrane of the loculus with 1–7 roundish, marginal sieve pores, about 70–100 mμ in diameter. In the intercalary bands of the same variety, collected off the Kammuri Island, Kyoto Pref., I found loculi of the same type (figs. 2, 2'''). In the cells of the latter specimen, the loculi in intercalary bands are hexagonal-rectangular or rectangular. The sieve membrane usually has 4 roundish sieve pores at the corners of the loculus.

St.: no. 62 (+; very rare).

Rhizosolenia bidens Karsten (Text fig. 1, B; Pl. II, figs. 3–3''), Phytopl. Antarkt. Meer.: 98, Pl. 9, figs. 13, 13 a, 13b (1905); Mills, Index Diat.: 1401 (1931); Boden, Journ. Mar. Res. **8**: 8 (1949).

Syn. *Rh. hebetata* f. *bidens* Heiden & Kolbe, Mar. Diat. Südpol.: 519, Pl. 8, figs. 158, 160, 161 (1928).

L. M. S, (fig. 3) Frustules cylindrical, straight, about 30–40μ in diameter. Calyptra elongated, obliquely pointed. At the end of the valve with two robust spines. The spine, at its base, with a conical cavity. Intercalary bands in form of rhomboidal scales, in two dorsiventral rows. Imbrications of the intercalary bands distinct.

E. M. S. (Text fig. 1, B; Pl. II, figs. 3', 3'') Fragments of the calyptra were observed electron-microscopically by the direct preparations. In the calyptra, frustule pores arranged in longitudinal rows, about 22–23 in 10μ. Frustule pores locular are likely rectangular in the calyptra. (In the present research, the frustules were somewhat impenetrable to the electron beam, and the full shapes of the loculi could not be observed.) The sieve membrane of a loculus with a linear, longitudinal slit-like sieve pore, about 50mμ in breadth. The cover membrane with a large elliptic cover pore, about 130–200 mμ long and about 80–100 mμ broad. Frustule pores of the same type as in the present species were found also in the intercalary bands of *Rhlzosoleuia hebetata* f. *semispina*, collected in Akashi Straits (fig. 4') and in the valve of *Gyrosigma Spencerii* (Okuno, Bot. Mag. Tokyo, **63**: 102, Pl. 3, fig. 2), *Pleurosigma aestuarii* (Kolbe, Sv. Bot. Tid. **45**: 637, Pl. 1, fig. 1, 2) and *Navicula crucigera* (Kolbe, l. c. pl. 2, fig. 3).

Endemic to the Antarctic Ocean. St.: no. 62 (+; very rare).

Rhizosolenia alata Brightwell (Pl. II, figs. 5, 5'), Boyer, Synop. North Amer. Diat. **1**: 101 (1926); Hustedt, Kieselalg. **1**: 600, fig. 344 (1930) & Atlas Diat. Pl. 317, figs. 1–7 (1920); Mills, Index Diat.: 1399 (1934); Cupp, Bull. Scrip. Inst. Ocean. **5**: 90, fig. 52–A (1943); Boden. Journ. Mar. Res. **8**: 8 (1949) & trans. R. Soc. S. Afr. **32**: 360, fig. 3a (1950).

L. M. S. (fig. 5) Frustules cylindrical, straight, about 22μ in diameter up to 1 mm in length. Calyptra rostrated, slightly twisted, without the apical spine, with a minute fissure at the end. At the base of the calyptra with a short spine which enters the fissure of the opposite calyptra. Intercalary bands scale-like, rhombic, with oblique lines of imbrication. Frustule pores almost invisible with the light microscope.

E. M. S. (fig. 5') Fragments of the intercalary bands were observed electron-microscopically by the direct preparations. Frustule pores about 3 in 1μ, arranged in three lines decussating at about 60 degrees. Frustule pores locular. The sieve membrane of a loculus with round sieve pores, about 50 mμ in diameter, about

7 in 1μ. The cover membrane with a large central pore, about 250–300 mμ in diameter. Through the cover pore, 2–6 sieve pores can be seen.

St.: no. 62 (+).

Rhizosolenia alata Brightwell f. **inermis** Hustedt (Text fig. 1, A; Pl. II, figs. 6, 6'), Kieselalg. **1**: 602, fig. 348 (1930); Mills, Index Diat.: 1400 (1934); Cupp, Bull. Scrip. Inst. Ocean. **5**: 94, fig. 52–E (1943); Boden, Joun. Mar, Res. **8**: 8 (1949).

Syn. *Ry. inermis* Castracane, Rep. Voy, Challenger, Bot, **2**: 71, pl. 24, figs. 7, 8, 13 (1886); Karsten, Phytopl. Antarkt. Meer.: 98, pl. 9, fig. 12 (I905); Heiden & Kolbe, Mar. Diat. Südpol.: 520 (1928).

L. M. S. (fig. 6) Frustules cylindrical, straight, about 11–15μ in diameter, about 160–360μ in length, Calyptra slightly twisted, tapering to the truncate apex. The present variety differs from the type in its smaller diameter and in its truncated, somewhat broad apex. Intercalary bands scale-like, rhombic, in two dorsiventral rows. Frustule pores almost invisible with the light microscope.

E. M. S. (Text fig. 1, A; Pl. II, fig. 6') Fragments of the intercalary bands were observed electron-microscopically by the direct preparations. Frustule pores about 5–6.5 in 1μ, arranged in three lines decussating at about 60 degrees. Frustule pores hexagonal, locular. The sieve membrane of the loculus seems to have 1–2 lens-shaped, parallel sieve pores (Text fig. 1, A). Sieve pores distinctly differ in their shapes and number from those of the type (cf. fig. 5'). In many loculi, the sieve pores slightly oblique to the pervalval axis of the cell. The cover membrane of the loculus, with a large roundish central cover pore, about 70–150 mμ in diameter.

St.: no. 27 (++); no. 39 (++); no. 62 (++).

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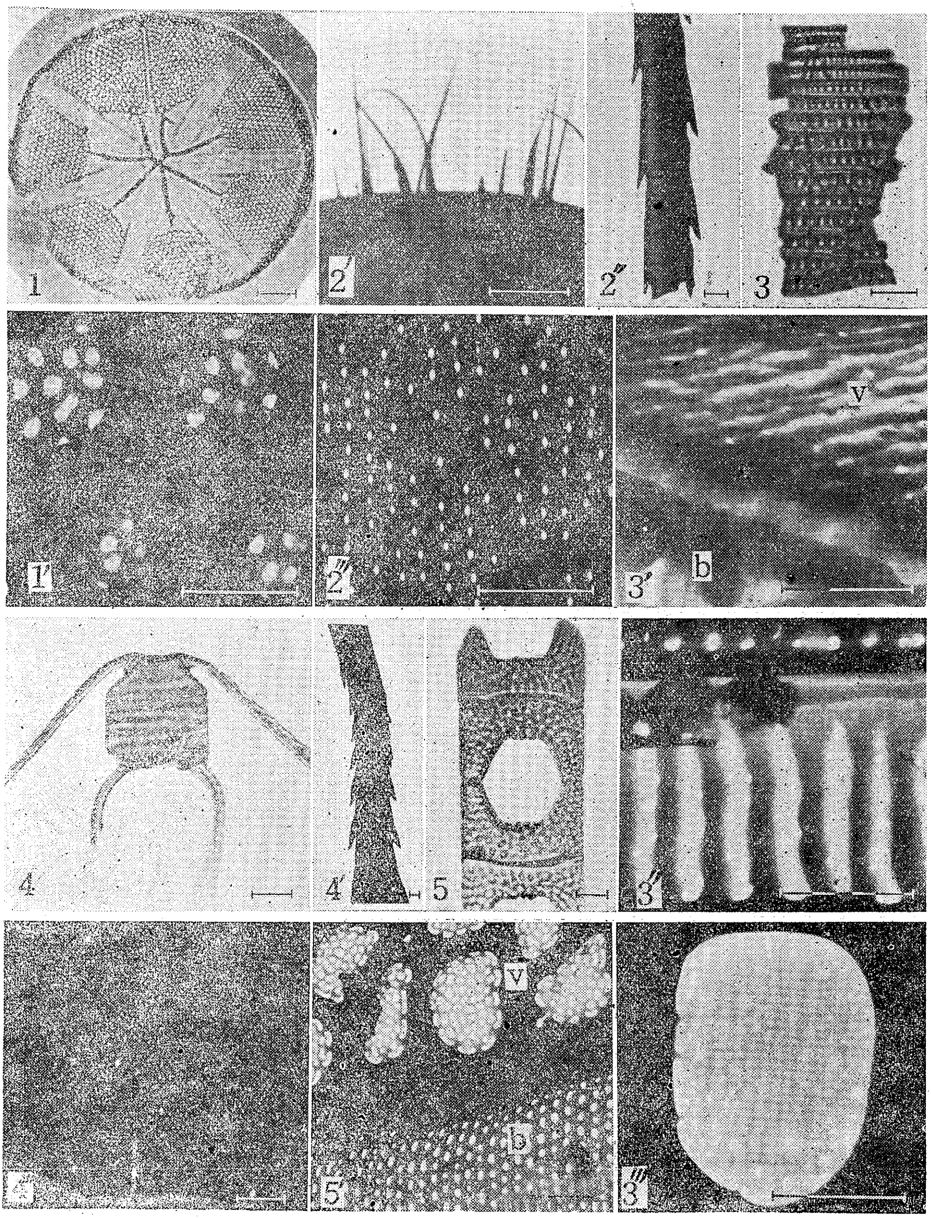
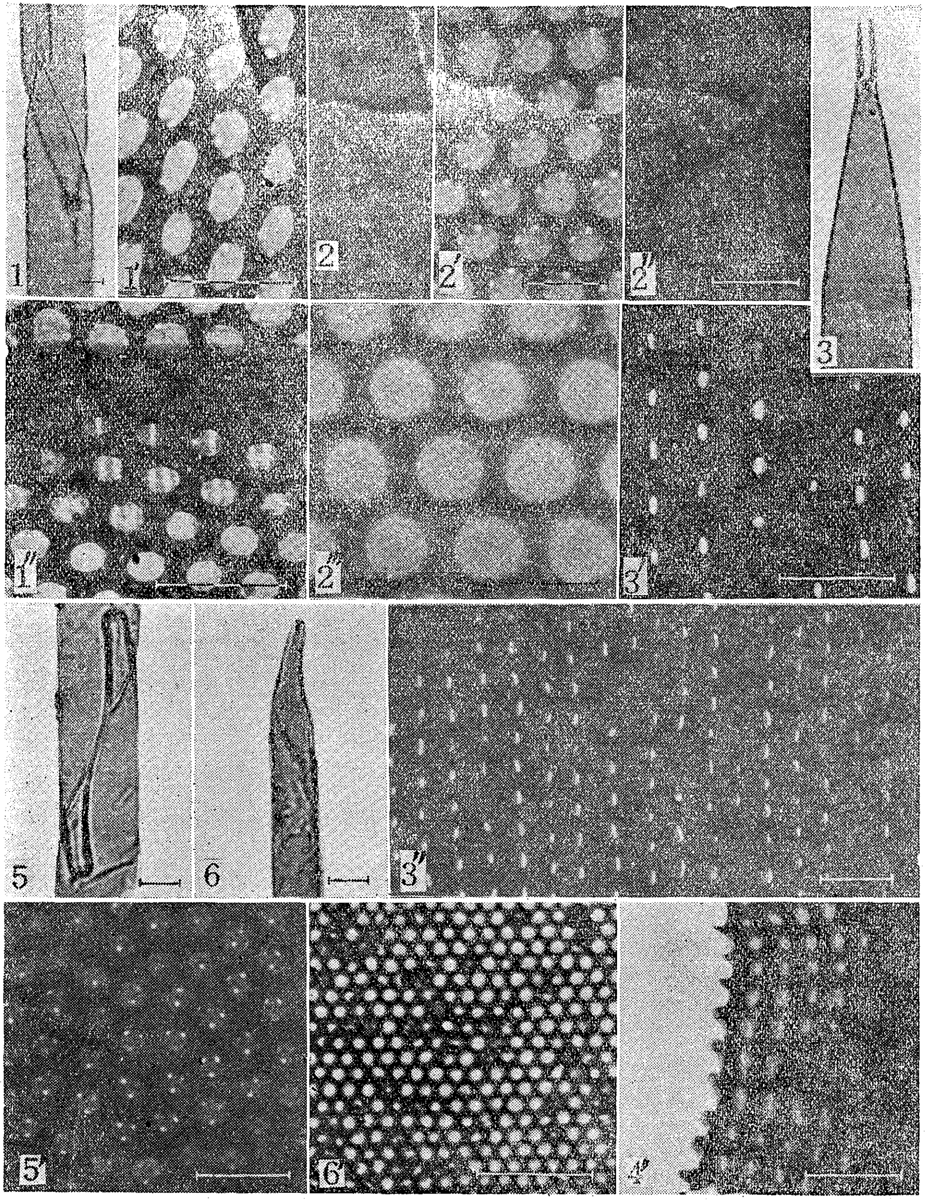


Pl. I. Fig. 1–1', *Asteromphalus Hookeri*. 2'–2''', *Corethron Valdiviae*. 3–3''', *Dactyliosolen antarcticus*. 4–4'', *Chaetoceros criophilum*. 5–5', *Eucampia balaustium*. 1, 3–5, Light micrographs. Scales: 10μ. 1'–5', Electron micrographs. Scales: 1μ.



Pl. II. Fig. 1–1'', *Rhizosolenia styliformis* var. *longispina*. 2–2''', var. *latissima*. 3–3'', *Rh. bidens*. 4', *Rh. hebetata* f. *semispina*. 5–5' *Rh. alata*. 6–6', f. *inermis*. 1–3,5,6, Light micrographs. Scales: 10μ. 1'–6', Electron micrographs. Scales: 1μ.